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The Infinite Bandwidth Company™

MIC4575

200kHz Simple 1A Buck Regulator

Final Information

General Description

The MIC4575 is a series of easy to use fixed and adjustable BiCMOS step-down (buck) switch-mode voltage regulators. The 200kHz MIC4575 duplicates the pinout and function of the 52kHz LM2575. The higher switching frequency may allow up to a 2:1 reduction in output filter inductor size.

The MIC4575 is available in 3.3V, and 5V fixed output versions or a 1.23V to 20V adjustable output version. Both versions are capable of driving a 1A load with excellent line and load regulation.

The feedback voltage is guaranteed to ±2% tolerance for adjustable versions, and the output voltage is guaranteed to ±3% for fixed versions, within specified voltages and load conditions. The oscillator frequency is guaranteed to ±10%.

In shutdown mode, the regulator draws less than 200µA standby current. The regulator performs cycle-by-cycle current limiting and thermal shutdown for protection under fault conditions.

This series of simple switch-mode regulators requires a minimum number of external components and can operate using a standard series of inductors. Frequency compensation is provided internally.

The MIC4575 is available in TO-220 (T) and TO-263 (U) packages for the industrial temperature range.

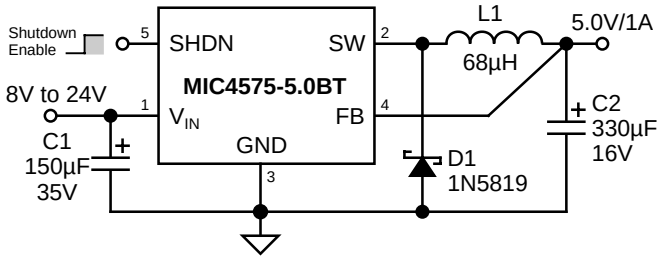
Features

- Fixed 200kHz operation
- 3.3V, 5V, and adjustable output versions
- Voltage over specified line and load conditions:
  - Fixed version: ±3% max. output voltage
  - Adjustable version: ±2% max. feedback voltage
- Guaranteed 1A switch current
- Wide 4V to 24V input voltage range
- Wide 1.23V to 20V output voltage range
- Requires minimum external components
- < 200µA typical shutdown mode
- 75% efficiency (adjustable version > 75% typical)
- Standard inductors and capacitors are 25% of typical LM2575 values.
- Thermal shutdown
- Overcurrent protection
- 100% electrical thermal limit burn-in

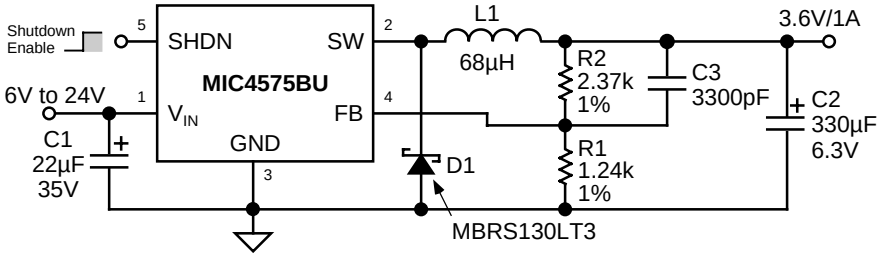
Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient preregulator for linear regulators
- On-card switching regulators
- Positive-to-negative converter (inverting buck-boost)
- Battery Charger
- Negative boost converter
- Step-down 6V to 3.3V for Intel Pentium™ and similar microprocessors

Typical Applications



Fixed Regulator

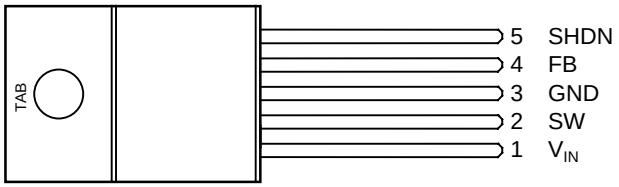


Adjustable Regulator

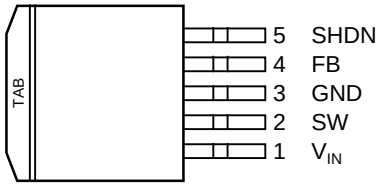
Ordering Information

Part Number	Voltage	Temperature Range	Package
MIC4575-3.3BT	3.3V	–40°C to +85°C	TO-220-5
MIC4575-5.0BT	5.0V	–40°C to +85°C	TO-220-5
MIC4575BT	Adjustable	–40°C to +85°C	TO-220-5
MIC4575-3.3BU	3.3V	–40°C to +85°C	TO-263-5
MIC4575-5.0BU	5.0V	–40°C to +85°C	TO-263-5
MIC4575BU	Adjustable	–40°C to +85°C	TO-263-5

Pin Configuration



5-Lead TO-220 (T)



5-Lead TO-263 (U)

Pin Description

Pin Number	Pin Name	Pin Function
1	V_{IN}	Supply Voltage (Input): Unregulated +4V to +40V supply voltage.
2	SW	Switch (Output): Emitter of NPN output switch. Connect to external storage inductor and Shottky diode.
3, TAB	GND	Ground
4	FB	Feedback (Input): Output voltage feedback to regulator. Connect to output of supply for fixed versions. Connect to 1.23V tap of resistive divider for adjustable versions.
5	SHDN	Shutdown (Input): Logic low enables regulator. Logic high (> 2.4V) shuts down regulator.

Absolute Maximum Ratings

Supply Voltage (V_{IN}) **Note 1** ..... +40V
Shutdown Voltage (V_{SHDN}) ..... –0.3V to +36V
Output Switch (V_{SW}) steady state ..... –1V
Storage Temperature (T_S) ..... –65°C to 150°C

Operating Ratings

Supply Voltage (V_{IN}) ..... +24V
Junction Temperature ..... +150°C
Package Thermal Resistance
TO-220, TO-263 (θ_{JA}) ..... 65°C/W
TO-220, TO-263 (θ_{JC}) ..... 2°C/W

Electrical Characteristics (Note 2)

V_{IN} = 12V; I_{LOAD} = 200mA; T_J = 25°C, **bold** values indicate –40°C ≤ T_J ≤ +85°C; unless noted.

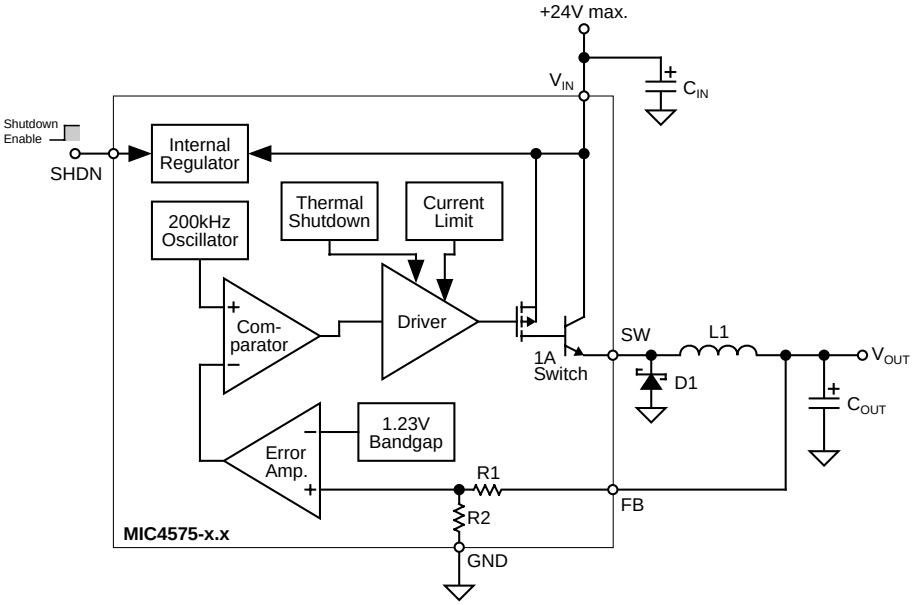
Parameter	Condition	Min	Typ	Max	Units
MIC4575 [Adjustable]					
Feedback Voltage		1.217	1.230	1.243	V
Feedback Voltage	8V ≤ V_{IN} ≤ 24V, 0.2A ≤ I_{LOAD} ≤ 1A	1.193 **1.180**	1.230	1.267 **1.280**	V V
Efficiency	I_{LOAD} = 1A, V_{OUT} = 5V		77		%
Feedback Bias Current			50	100 **500**	nA nA
MIC4575-3.3					
Output Voltage		3.234	3.3	3.366	V
Output Voltage	6V ≤ V_{IN} ≤ 24V, 0.2A ≤ I_{LOAD} ≤ 1A	3.168 **3.135**	3.3	3.432 **3.465**	V V
Efficiency	I_{LOAD} = 1A		72		%
MIC4575-5.0					
Output Voltage		4.900	5.0	5.100	V
Output Voltage	8V ≤ V_{IN} ≤ 24V, 0.2A ≤ I_{LOAD} ≤ 1A	4.800 **4.750**	5.0	5.200 **5.250**	V V
Efficiency	I_{LOAD} = 1A		77		%
MIC4575 / -3.3 / -5.0					
Oscillator Frequency		180	200	220	kHz
Saturation Voltage	I_{OUT} = 1A		1	1.3 **1.5**	V V
Maximum Duty Cycle (On)	FB connected to 0V	90	95		%
Current Limit	Peak Current, t_{ON} ≤ 3µs	1.7 **1.3**	2.2	3.0 **3.2**	A A
Output Leakage Current	V_{IN} = 24V, FB connected to 0V Output = 0V Output = –1V		 0 7.5	 2 30	 mA mA
Quiescent Current			5	10	mA
Standby Quiescent Current	SHDN = 5V (regulator off)		50	200	µA
SHDN Input Logic Level	V_{OUT} = 0V (regulator off)	2.2 **2.4**	1.4		V V
	V_{OUT} = 3.3 or 5V (regulator on)		1.2	1.0 **0.8**	V V
SHDN Input Current	SHDN = 5V (regulator off) SHDN = 0V (regulator on)	 –10	4 0.01	30 10	µA µA

General Note: Devices are ESD protected, however, handling precautions are recommended.

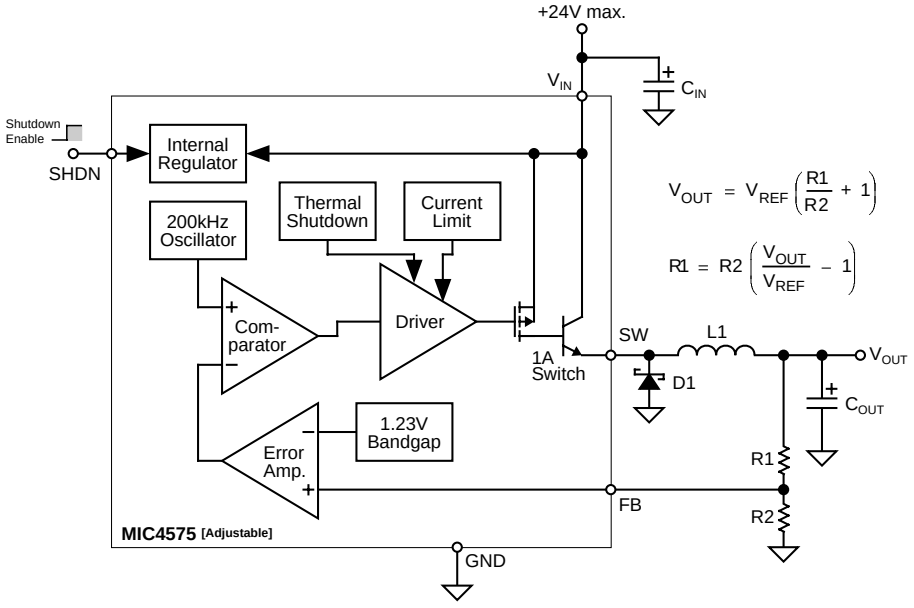
Note 1: The MIC4575 is not guaranteed to survive a short circuit to ground for input voltage above 24V.

Note 2: Specification for packaged product only.

Block Diagrams



Block Diagram with External Components
Fixed Step-Down Regulator



Block Diagram with External Components
Adjustable Step-Down Regulator

Functional Description

The MIC4575 is a variable duty cycle switch-mode regulator with an internal power switch. Refer to the block diagrams.

Supply Voltage

The MIC4575 operates from a +4V to +24V unregulated input. Highest efficiency operation is from a supply voltage around +15V.

Enable/Shutdown

The shutdown (SHDN) input is TTL compatible. Ground the input if unused. A logic-low enables the regulator. A logic-high shuts down the internal regulator which reduces the current to typically 50µA.

Feedback

Fixed versions of the regulator have an internal resistive divider from the feedback (FB) pin. Connect FB directly to the output line.

Adjustable versions require an external resistive voltage divider from the output voltage to ground, connected from the 1.23V tap to FB.

Duty Cycle Control

A fixed-gain error amplifier compares the feedback signal with a 1.23V bandgap voltage reference. The resulting error amplifier output voltage is compared to a 200kHz sawtooth waveform to produce a voltage controlled variable duty cycle output.

A higher feedback voltage increases the error amplifier output voltage. A higher error amplifier voltage (comparator inverting input) causes the comparator to detect only the peaks of the sawtooth, reducing the duty cycle of the comparator output. A lower feedback voltage increases the duty cycle.

Output Switching

When the internal switch is on, an increasing current flows from the supply $V_{IN,}$ through external storage inductor L1, to output capacitor C_{OUT} and the load. Energy is stored in the inductor as the current increases with time.

When the internal switch is turned off, the collapse of the magnetic field in L1 forces current to flow through fast recovery diode D1, charging C_{OUT}.

Output Capacitor

External output capacitor C_{OUT} provides stabilization and reduces ripple.

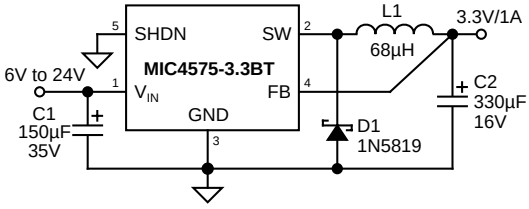
Return Paths

During the on portion of the cycle, the output capacitor and load currents return to the supply ground. During the off portion of the cycle, current is being supplied to the output capacitor and load by storage inductor L1, which means that D1 is part of the high-current return path.

Applications Information

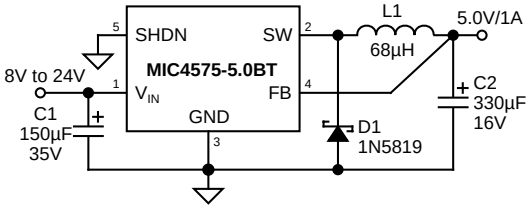
The applications circuits that follow have been constructed and tested. Refer to Application Note 15 for additional information, including efficiency graphs and manufacturer's addresses and telephone numbers for most circuits.

For a mathematical approach to component selection and circuit design, refer to Application Note 14.



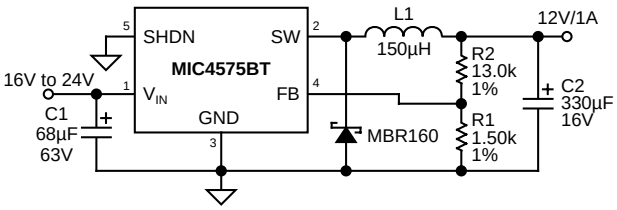
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C2	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
L1	Sumida	RCH106-680K, DCR = 0.22Ω
L1	Bi	HM77-11003, DCR = 0.233Ω, **Note 2**

Figure 1. 6V–24V to 3.3V/1A Buck Converter Through Hole



C1	Nichicon	UPL1J151MPH, ESR = 0.12Ω
C2	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
L1	Sumida	RCH106-680K, DCR = 0.22Ω
L2	Bi	HM77-11003, DCR = 0.233Ω, **Note 2**

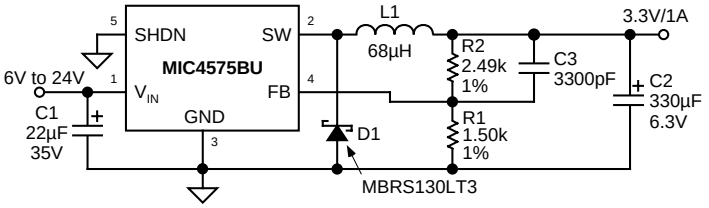
Figure 2. 8V–24V to 5V/1A Buck Converter Through Hole



C1	Nichicon	UPL1J680MPH, ESR = 0.17Ω
C2	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	MBR160
L1	Sumida	RCH110-151K, DCR = 0.23Ω

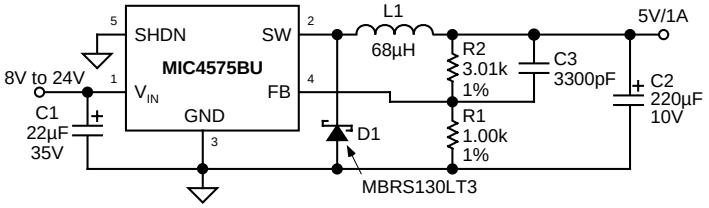
Note 2: Surface-mount component.

Figure 3. 16V–24V to 12V/1A Buck Converter, Through Hole



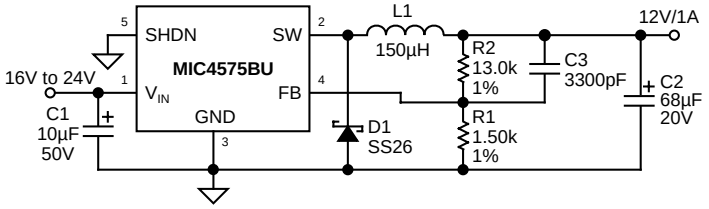
C1 AVX TPSE226M035R0300, ESR = 0.3Ω
C2 AVX TPSE337M006R0100, ESR = 0.1Ω
D1 Motorola MBRS130LT3
L1 Coiltronics CTX68-4P, DCR = 0.238Ω

Figure 4. 6V–24V to 3.3V/1A Buck Converter Low-Profile Surface Mount



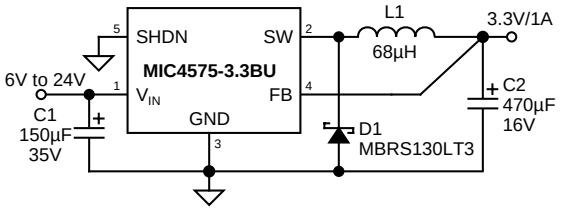
C1 AVX TPSE226M035R0300, ESR = 0.3Ω
C2 AVX TPSE227M010R0100, ESR = 0.1Ω
D1 Motorola MBRS130LT3
L1 Coiltronics CTX68-4P, DCR = 0.238Ω

Figure 5. 8V–24V to 5V/1A Buck Converter Low-Profile Surface Mount



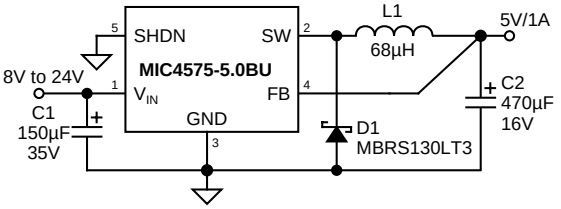
C1 Tokin C55YU1H106Z
C2 AVX TPSE686M020R0150, ESR = 0.15Ω
D1 General Instruments SS26
L1 Coiltronics CTX150-4, DCR = 0.372Ω

Figure 6. 16V–24V to 12V/1A Buck Converter Low-Profile Surface Mount



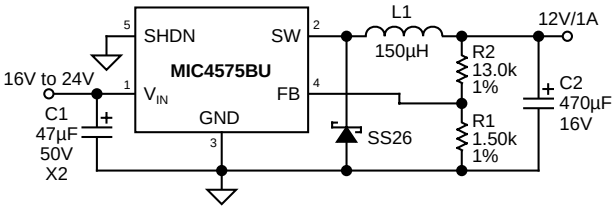
C1 Sanyo 35CV150GX, ESR = 0.17Ω
C2 Sanyo 16CV470GX, ESR = 0.17Ω
D1 Motorola MBRS130LT3
L1 Coilcraft DO3316P-683, DCR = 0.16Ω
L1 Bi HM77-11003, DCR = 0.233Ω

Figure 7. 6V–24V to 3.3V/1A Buck Converter Lower-Cost Surface Mount



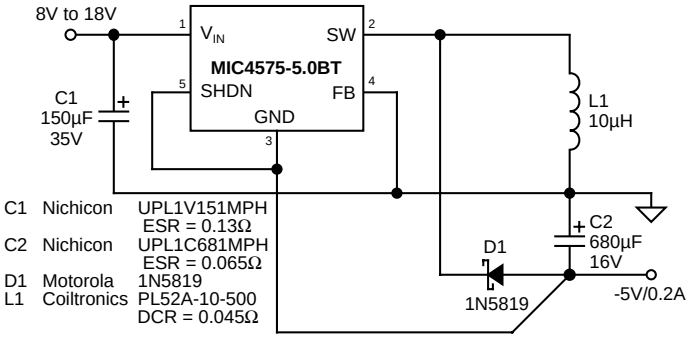
C1 Sanyo 35CV150GX, ESR = 0.17Ω
C2 Sanyo 16CV470GX, ESR = 0.17Ω
D1 Motorola MBRS130LT3
L1 Coilcraft DO3316P-683, DCR = 0.16Ω
L1 Bi HM77-11003, DCR = 0.233Ω

Figure 8. 8V–24V to 5V/1A Buck Converter Lower-Cost Surface Mount



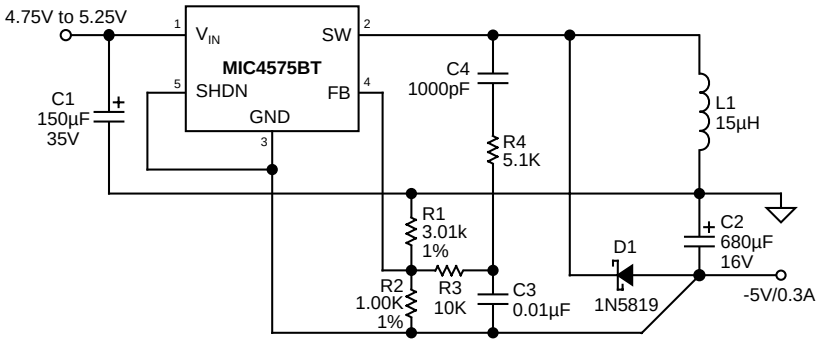
C1 Nichicon UUX1H470MT1GS, ESR = 0.4Ω
C2 Sanyo 16CV470GX, ESR = 0.17Ω
D1 General Instruments SS26
L1 Coiltcraft DO5022P-154, DCR = 0.218Ω

Figure 9. 16V–24V to 12V/1A Buck Converter Lower-Cost Surface Mount



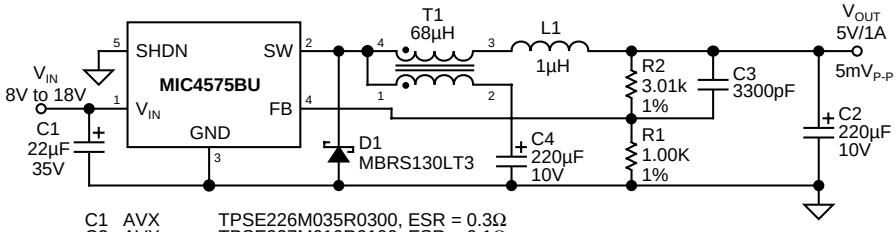
C1 Nichicon UPL1V151MPH
ESR = 0.13Ω
C2 Nichicon UPL1C681MPH
ESR = 0.065Ω
D1 Motorola 1N5819
L1 Coiltronics PL52A-10-500
DCR = 0.045Ω

Figure 10. 8V–18V to –5V/0.2A Buck-Boost Converter Through Hole



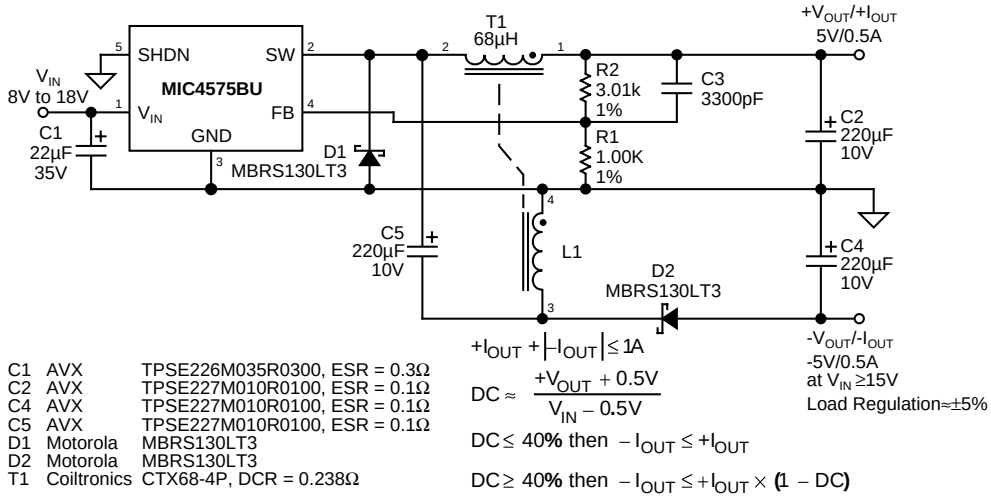
C1 Nichicon UPL1V151MPH, ESR = 0.12Ω
C2 Nichicon UPL1C681MPH, ESR = 0.065Ω
D1 Motorola 1N5819
L1 Coiltronics PL52A-15-500, DCR = 0.054Ω

Figure 11. 5V to –5V/0.3A Buck-Boost Converter Through Hole



C1 AVX TPSE226M035R0300, ESR = 0.3Ω
C2 AVX TPSE227M010R0100, ESR = 0.1Ω
C4 AVX TPSE227M010R0100, ESR = 0.1Ω
D1 Motorola MBRS130LT3
T1 Coiltronics CTX68-4P, DCR = 0.238Ω
L1 Coilcraft DO1608C-102

Figure 12. Low Output-Noise Regulator (5mV Output Ripple)



C1 AVX TPSE226M035R0300, ESR = 0.3Ω
C2 AVX TPSE227M010R0100, ESR = 0.1Ω
C4 AVX TPSE227M010R0100, ESR = 0.1Ω
C5 AVX TPSE227M010R0100, ESR = 0.1Ω
D1 Motorola MBRS130LT3
D2 Motorola MBRS130LT3
T1 Coiltronics CTX68-4P, DCR = 0.238Ω

$+I_{OUT} + \left|-I_{OUT}\right| \leq 1A$

$DC \approx \frac{+V_{OUT} + 0.5V}{V_{IN} - 0.5V}$

$DC \leq 40\%$ then $-I_{OUT} \leq +I_{OUT}$

$DC \geq 40\%$ then $-I_{OUT} \leq +I_{OUT} \times (1 - DC)$

Figure 13. Split ±5V Supply

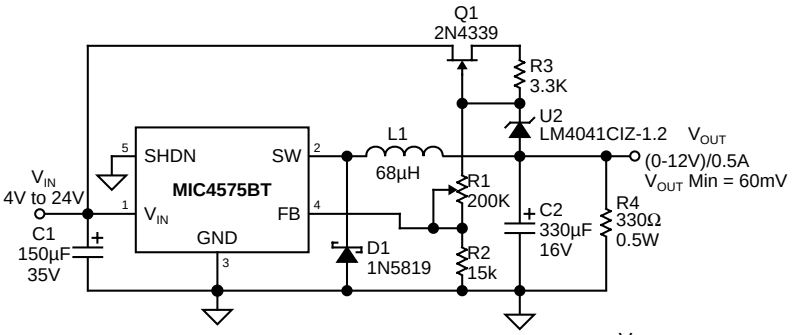


Figure 14. Adjustable (0V–12V) Output-Voltage Regulator

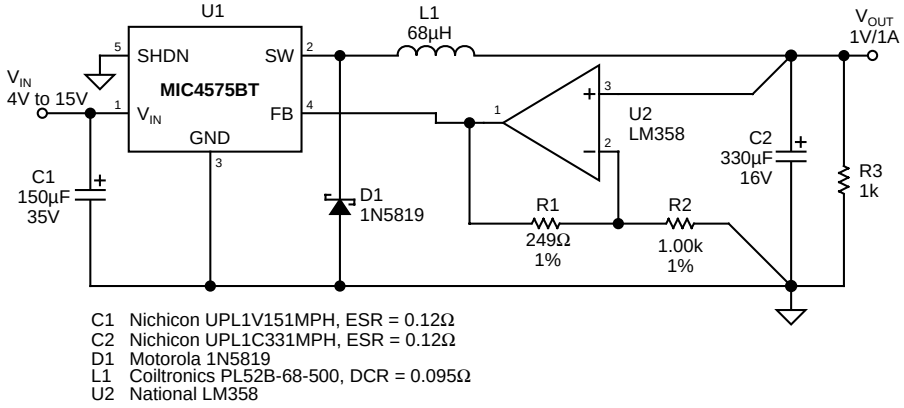


Figure 15. Low Output-Voltage Regulator (1V)

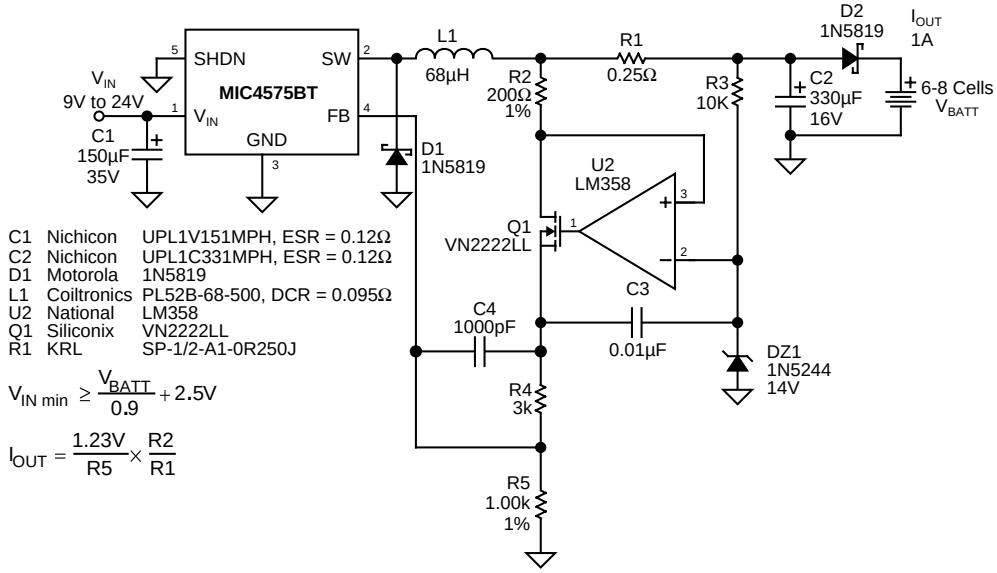
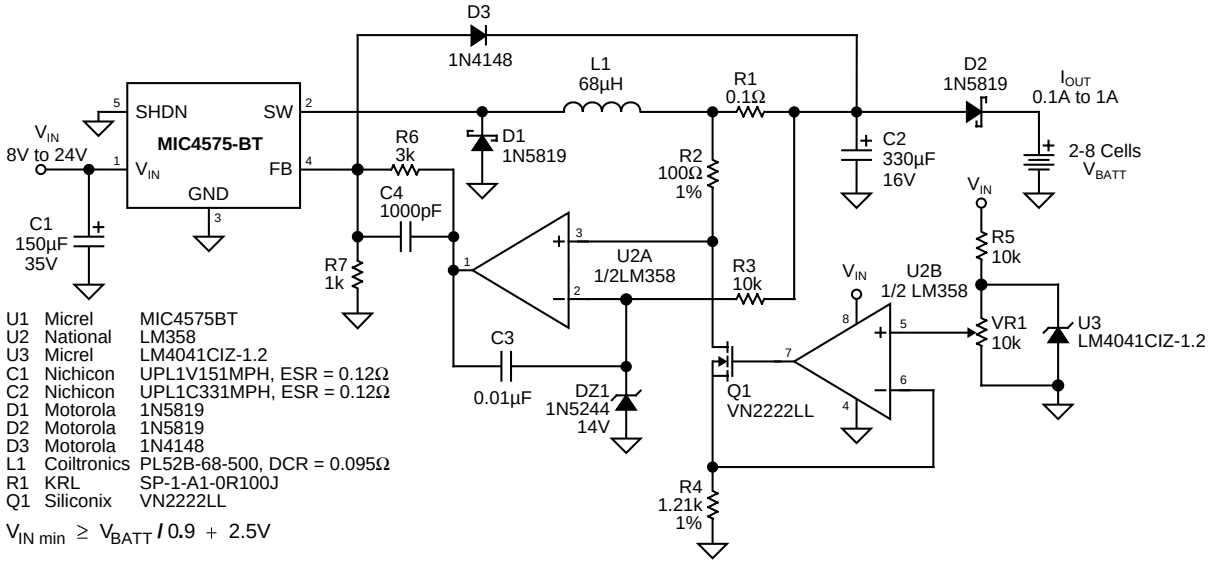


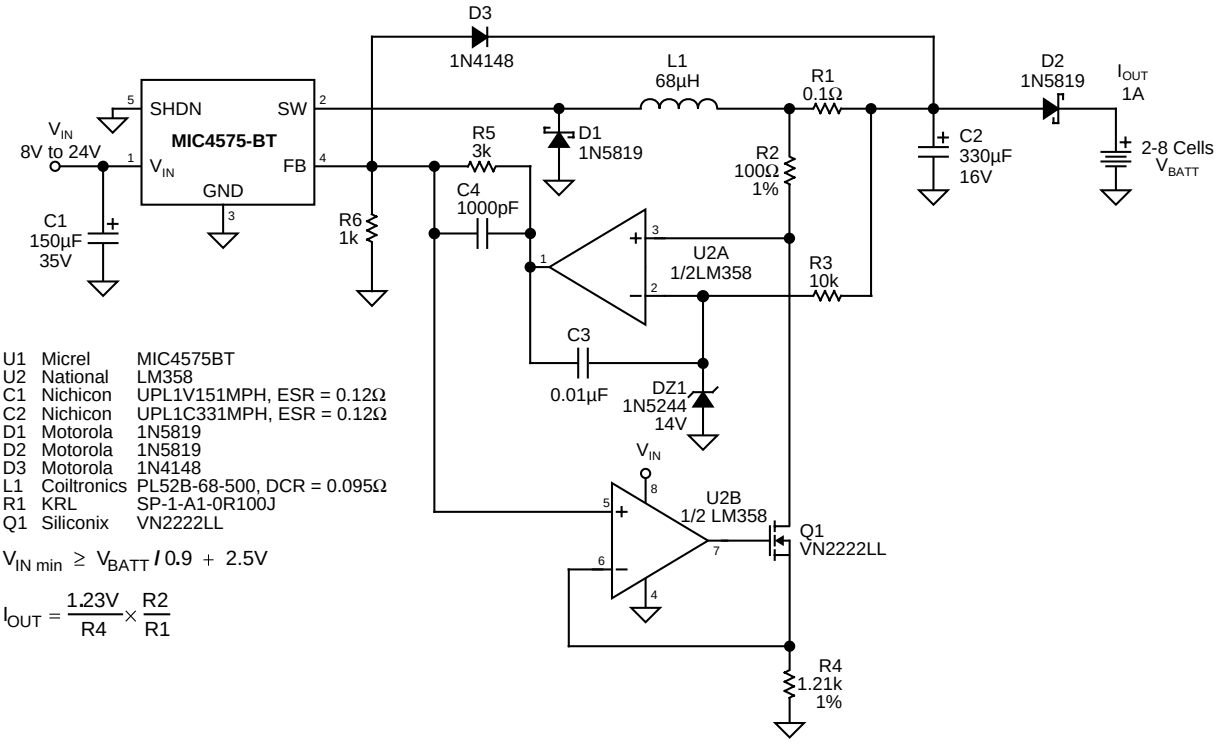
Figure 16. 1A Battery Charger (6–8 cells)



U1	Micrel	MIC4575BT
U2	National	LM358
U3	Micrel	LM4041CIZ-1.2
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C2	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
D2	Motorola	1N5819
D3	Motorola	1N4148
L1	Coiltronics	PL52B-68-500, DCR = 0.095Ω
R1	KRL	SP-1-A1-0R100J
Q1	Siliconix	VN2222LL

$V_{IN\ min} \geq V_{BATT} / 0.9 + 2.5V$

Figure 17. 0.1A–1A Variable-Current Battery Charger



U1	Micrel	MIC4575BT
U2	National	LM358
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C2	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
D2	Motorola	1N5819
D3	Motorola	1N4148
L1	Coiltronics	PL52B-68-500, DCR = 0.095Ω
R1	KRL	SP-1-A1-0R100J
Q1	Siliconix	VN2222LL

$V_{IN\ min} \geq V_{BATT} / 0.9 + 2.5V$

$$I_{OUT} = \frac{1.23V}{R4} \times \frac{R2}{R1}$$

Figure 18. 1A Battery Charger (2–8 Cells)

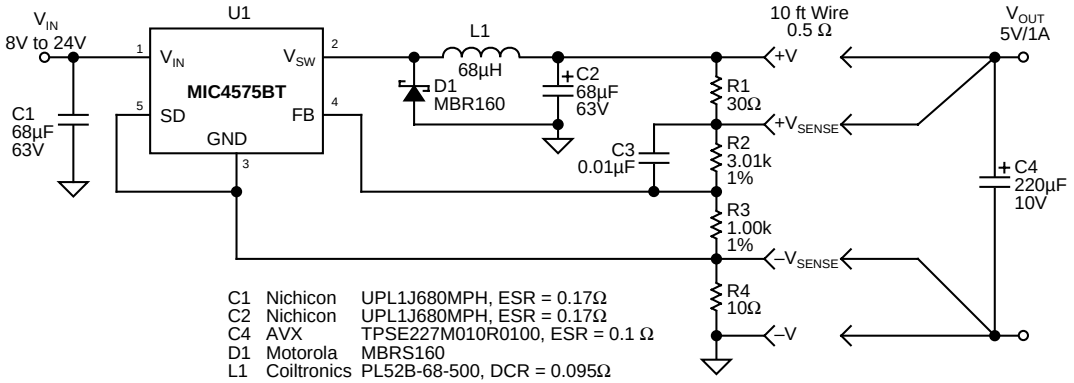


Figure 19. Remote-Sensing Regulator

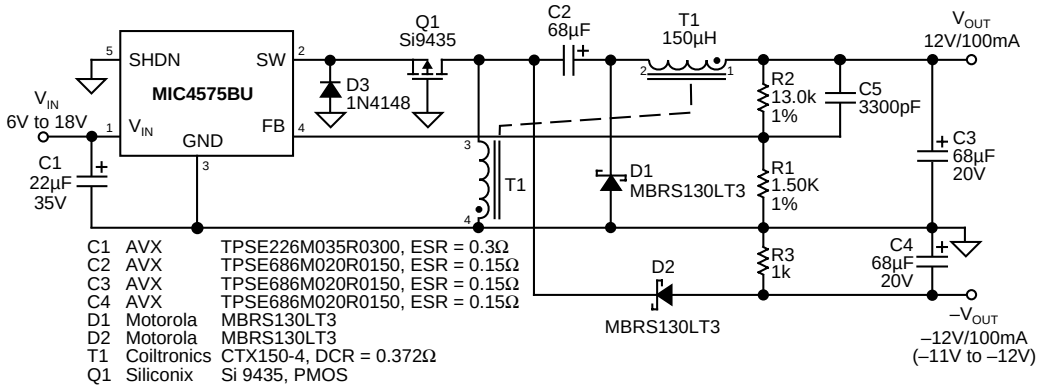
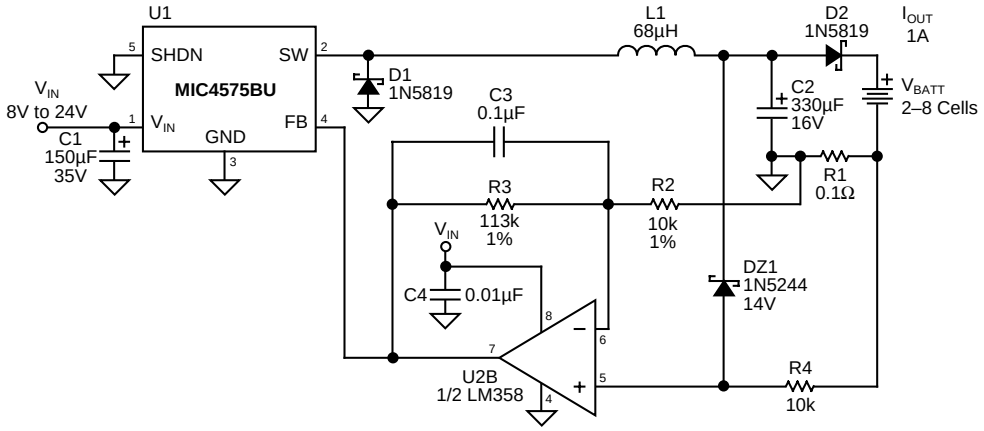


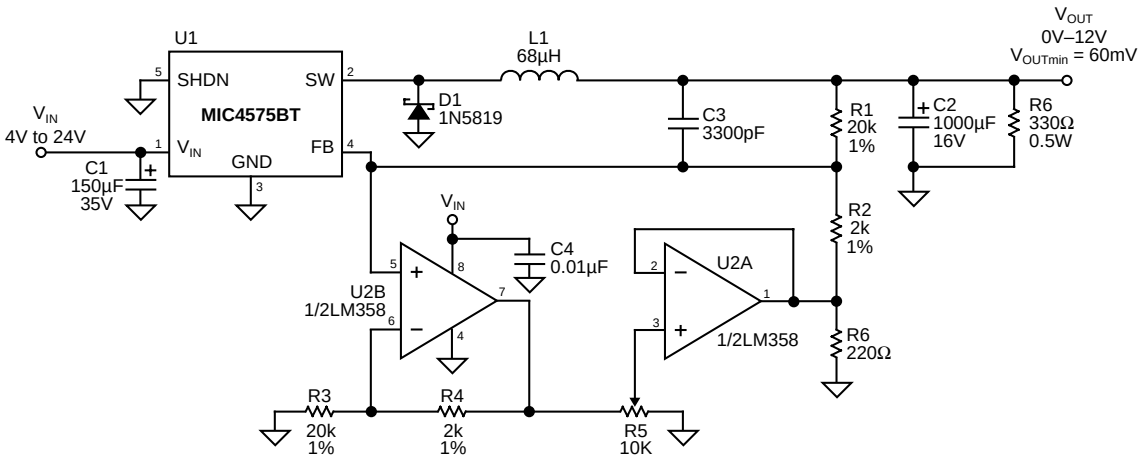
Figure 20. 6V–18V to Split ±12V/100mA Supply



$$V_{IN\ min} > = \frac{V_{BATT}}{0.9} + 2.5V$$

$$I_{OUT} = \frac{1.23V}{R1} \times \frac{R2}{R2 + R3}$$

Figure 21. 1A Battery Charger



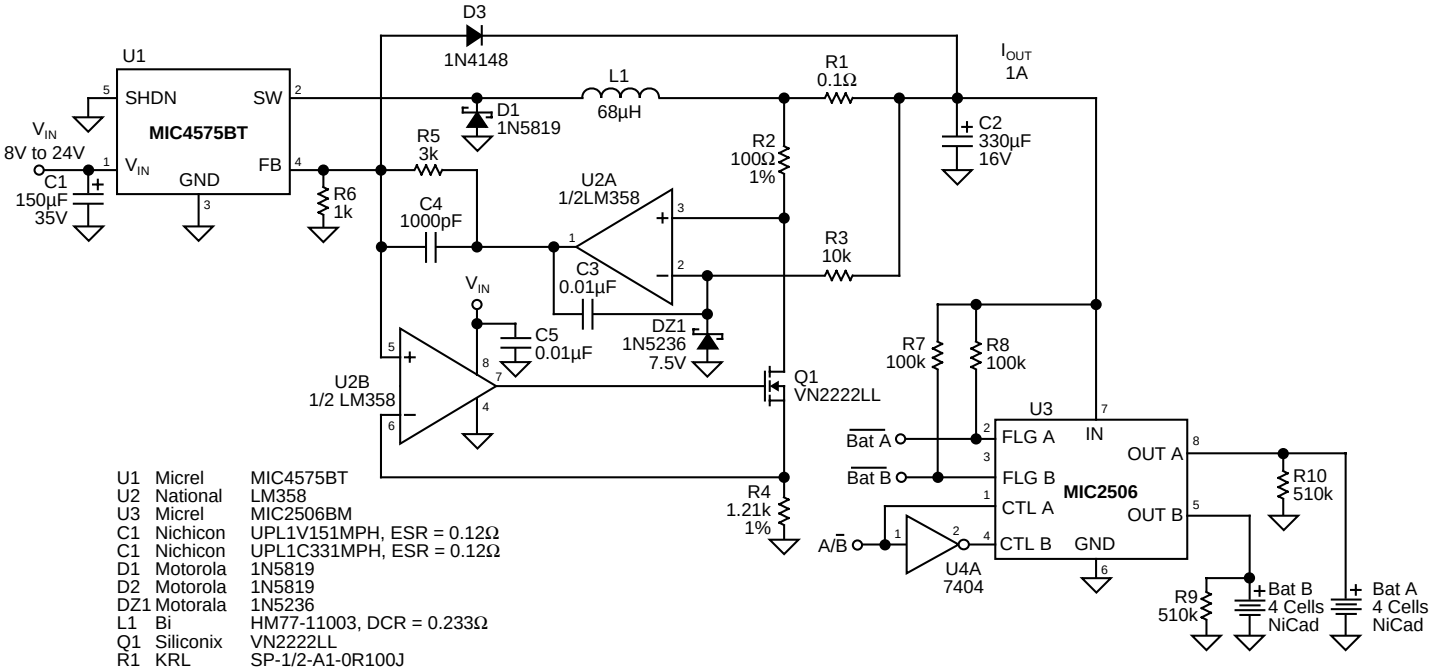
U1	Micrel	MIC4575BT
U2	National	LM358
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C2	Nichicon	UPL1C102MPH, ESR = 0.047Ω
D1	Motorola	1N5819
L1	Bi	HM77-11003, DCR = 0.233Ω

$$V_{IN\ min} > = \frac{V_{OUT}}{0.9} + 2.5V$$

$$V_{OUT\ max} = 1.23V \times \left(1 + \frac{R1}{R2}\right)$$

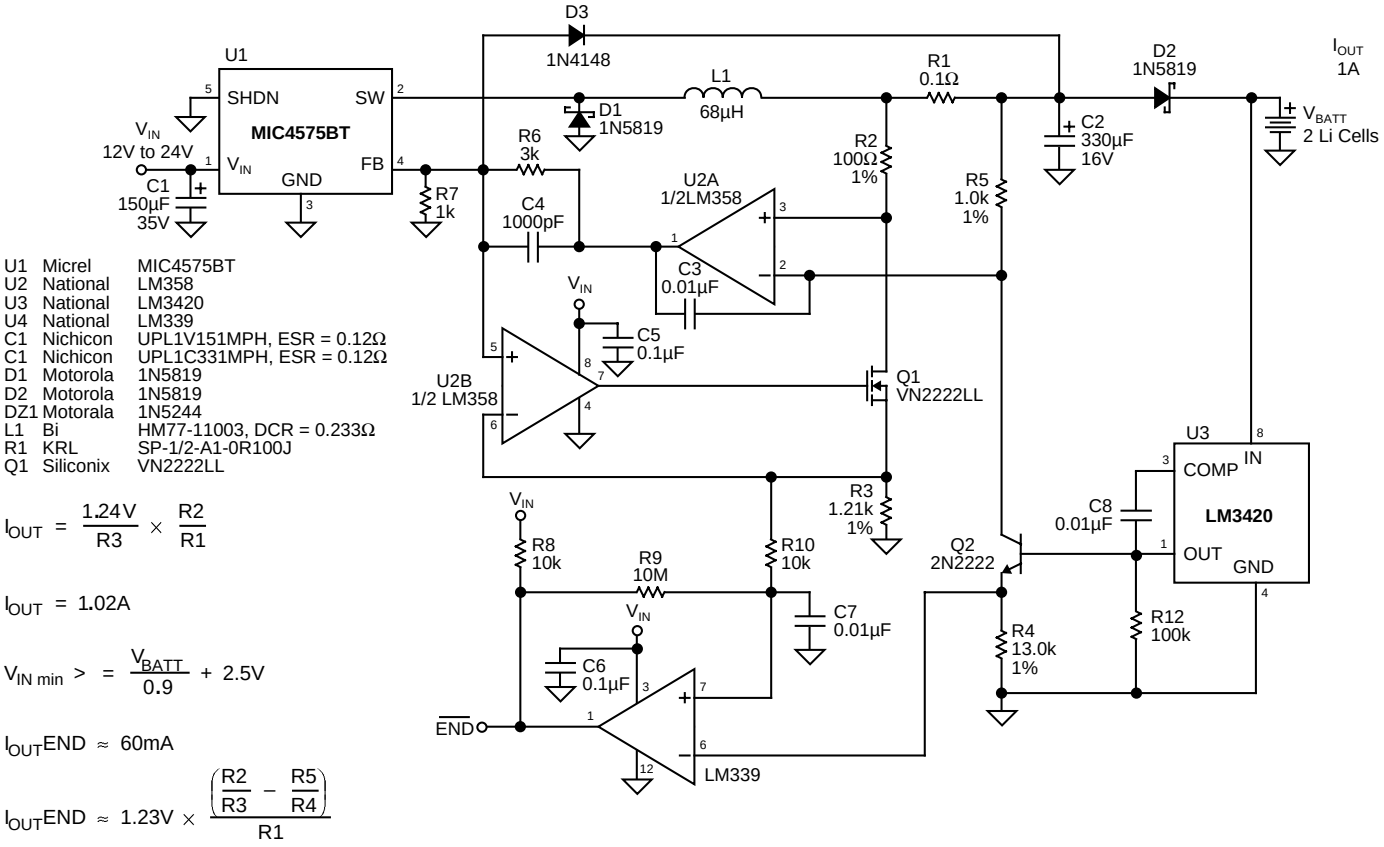
R1 = R3 and R2 = R4

Figure 22. Improved Adjustable Output-Voltage Regulator (0V–12V)



U1	Micrel	MIC4575BT
U2	National	LM358
U3	Micrel	MIC2506BM
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C1	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
D2	Motorola	1N5819
DZ1	Motorala	1N5236
L1	Bi	HM77-11003, DCR = 0.233Ω
Q1	Siliconix	VN2222LL
R1	KRL	SP-1/2-A1-0R100J

Figure 23. Switchable Battery-Pack Charger



U1	Micrel	MIC4575BT
U2	National	LM358
U3	National	LM3420
U4	National	LM339
C1	Nichicon	UPL1V151MPH, ESR = 0.12Ω
C1	Nichicon	UPL1C331MPH, ESR = 0.12Ω
D1	Motorola	1N5819
D2	Motorola	1N5819
DZ1	Motorala	1N5244
L1	Bi	HM77-11003, DCR = 0.233Ω
R1	KRL	SP-1/2-A1-0R100J
Q1	Siliconix	VN2222LL

$$I_{OUT} = \frac{1.24V}{R3} \times \frac{R2}{R1}$$

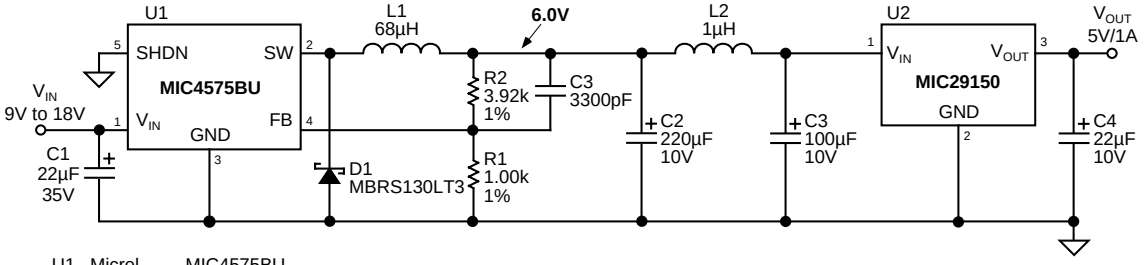
$$I_{OUT} = 1.02A$$

$$V_{IN\ min} > = \frac{V_{BATT}}{0.9} + 2.5V$$

$$I_{OUT}END \approx 60mA$$

$$I_{OUT}END \approx 1.23V \times \frac{\left(\frac{R2}{R3} - \frac{R5}{R4}\right)}{R1}$$

Figure 24. Lithium-Ion Battery Charger with End-of-Charge Flag

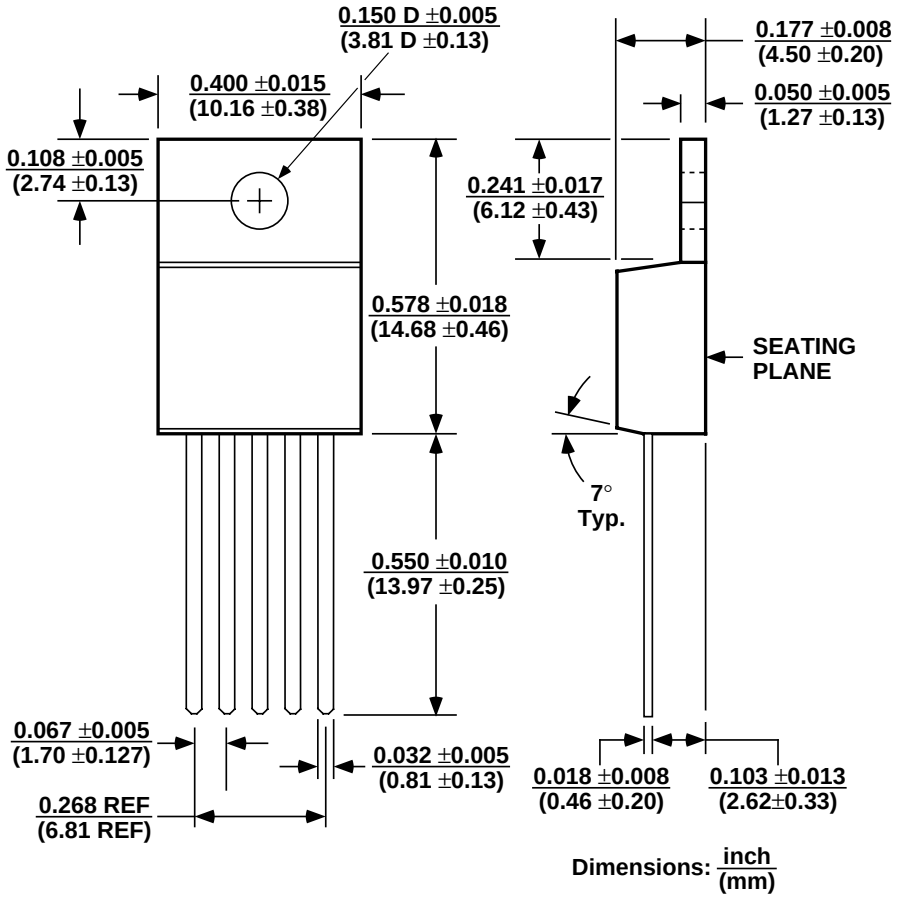


U1	Micrel	MIC4575BU
U2	Micrel	MIC29150-5.0BU
C1	AVX	TPSE226M035R0300, ESR = 0.3Ω
C2	AVX	TPSE227M010R0100, ESR = 0.1Ω
C3	AVX	TPSE106M010R0200, ESR = 0.2Ω
C4	Sprague	293D226X0010C2W
D1	Motorola	MBRS130LT3
D2	Motorola	MBRS130LT3
L1	Bi	HM77-11003, DCR = 0.233Ω
L2	Coilcraft	D016087C-102, DCR = 0.05Ω

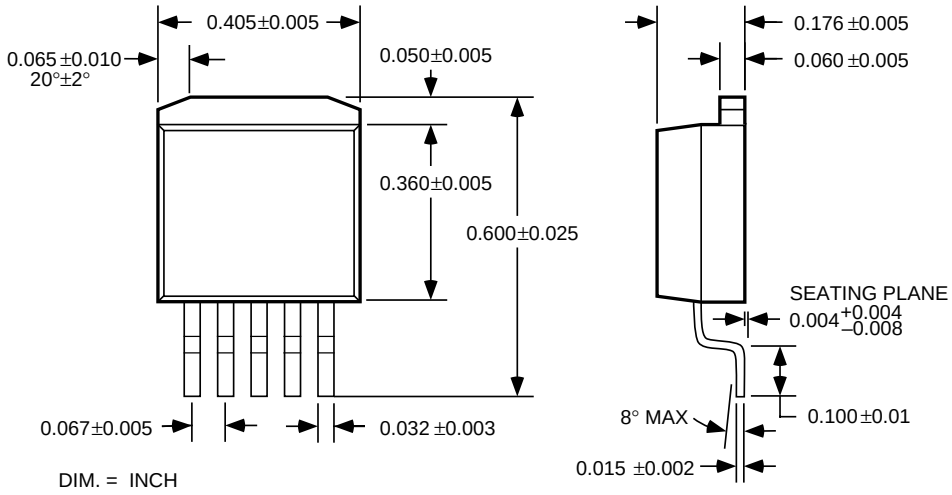
$$V_{OUT} = 1.23 \times \left(1 + \frac{R2}{R1}\right)$$

Figure 25. Low Output-Noise Regulator (<1mV)

Package Information



5-Lead TO-220 (T)



5-Lead TO-263 (U)

MICREL INC. 1849 FORTUNE DRIVE SAN JOSE, CA 95131 USA

TEL + 1 (408) 944-0800 FAX + 1 (408) 944-0970 WEB http://www.micrel.com

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